PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-022981

(43)Date of publication of application : 23.01.2002

(51)Int.Cl. G02B 6/12
G02B 6/42

(21)Application number : 2000-204198

(22)Date of filing : 05.07.2000

(71)Applicant : NEC CORP

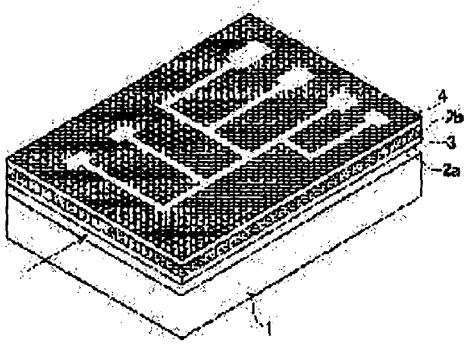
(72)Inventor : YAMADA HIROHITO

(54) PHOTONIC CRYSTAL MULTIPLAYERED SUBSTRATE AND METHOD FOR MANUFACTURING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a novel form of photonic crystal optical circuit which overcomes the weak point of the photonic crystal optical circuits as the prior art and realizes higher density integration by multiple layering of the optical circuits and optical wiring and a method for manufacturing the same.

SOLUTION: The photonic crystal multilayered substrate is constituted by forming photonic crystal layers 3 and 4 consisting of photonic crystals having the structure two-dimensionally or three-dimensionally periodically modulated in refractive index with the sizes of about the wavelength of light, and a slab waveguide type photonic crystal structure having the photonic crystal layers 3 and 4 as cores by sandwiching these layers with clad layers 2a and 2b consisting of materials having the value of their average refractive index smaller than the average refractive index of the materials of the photonic crystal layers 3 and 4, and laminating a plurality of such slab waveguide type photonic crystal structures in a thickness direction, and also the method for manufacturing the same is provided.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The photograph nick crystal multilayer substrate to which it has the following, and has the slab waveguide type photograph nick crystal structure which put the aforementioned photograph nick crystal layer in the aforementioned clad layer, and the aforementioned photograph nick crystal structure is characterized by carrying out two or more laminatings in the thickness direction. The photograph nick crystal layer which a refractive index becomes from the photograph nick crystal which has the structure modulated two-dimensional or periodically three dimensions in the size about [of light] wavelength. The clad layer which consists of material into which a refractive index differs from the aforementioned photograph nick crystal.
[Claim 2] The photograph nick crystal multilayer substrate to which the refractive index of the material of the aforementioned clad layer is characterized by being smaller than the average refractive index of the aforementioned photograph nick crystal layer in a photograph nick crystal multilayer substrate given in the aforementioned claim 1.
[Claim 3] The photograph nick crystal multilayer substrate characterized by forming the multilayer optical circuit by forming an optical device in the aforementioned claim 2 in the photograph nick crystal multilayer substrate of a publication at two or more photograph nick crystal layers of this substrate.
[Claim 4] The photograph nick crystal multilayer substrate to which the aforementioned clad layer is characterized by the bird clapper in a photograph nick crystal multilayer substrate given in any 1 term of the aforementioned claims 1-3 from the multilayer which carried out the laminating of two or more kinds of matter with which refractive indexes differ by turns.
[Claim 5] The photograph nick crystal multilayer substrate to which it sets to a photograph nick crystal multilayer substrate given in any 1 term of the aforementioned claims 1-3, and the aforementioned clad layer is characterized by the bird clapper from the photograph nick crystal into which a refractive index has the structure modulated two-dimensional or periodically three dimensions.
[Claim 6] The photograph nick crystal multilayer substrate characterized by having the optical reflection property in which the multilayer or photograph nick crystal which constitutes the aforementioned clad layer has a big reflection factor to the light wave of specific wavelength in a photograph nick crystal multilayer substrate given in the aforementioned claims 4 or 5.
[Claim 7] The photograph nick crystal multilayer substrate characterized by having the optical reflection property in which the multilayer or photograph nick crystal which constitutes the aforementioned clad layer has a big reflection factor to the light wave introduced into the optical device formed in this substrate in a photograph nick crystal multilayer substrate given in the aforementioned claim 6.
[Claim 8] The photograph nick crystal multilayer substrate characterized by equipping the optical device formed in either of the aforementioned claims 3-7 in the photograph nick crystal multilayer substrate of a publication at this substrate with the mechanism for delivering a lightwave signal between layers.
[Claim 9] The mechanism for delivering a lightwave signal to the aforementioned claim 8 between layers in the photograph nick crystal multilayer substrate of a publication Take out the light wave spread along with the optical waveguide within the circuit side of the optical device formed in the photograph nick crystal layer in the direction perpendicular to a circuit side. Or the photograph nick crystal multilayer substrate characterized by being the mode converter changed so that the light wave which carries out incidence may be spread along with the optical waveguide within a circuit side from a direction perpendicular to a circuit side.
[Claim 10] The photograph nick crystal multilayer substrate characterized by being the mode converter which takes out the light wave which spreads the aforementioned optical waveguide to the perpendicular direction of a circuit side according to the light wave which spreads the aforementioned optical waveguide and the resonating resonance mechanism in_which the aforementioned mode converter was formed in the aforementioned claim 9 in the photograph

nick crystal multilayer substrate of a publication at a part for the trailer of the optical waveguide within the circuit side of the aforementioned photograph nick crystal layer.

[Claim 11] The photograph nick crystal multilayer substrate to which the aforementioned mode converter is characterized by the bird clapper in the photograph nick crystal multilayer substrate of the claim 10 aforementioned publication from the resonance section prepared by surrounding the circumference centering on the configuration which resonates to the light wave to which an optical waveguide is spread and the hole which has a size formed in a part for the trailer of the optical waveguide within the circuit side of the aforementioned photograph nick crystal layer, and its hole.

[Claim 12] In the photograph nick crystal multilayer substrate of the claim 8 aforementioned publication, the lightwave signal from the optical device formed in the circuit side of a photograph nick crystal layer The mechanism for delivering to the optical waveguide formed in another photograph nick crystal layer The light wave spread along with the optical waveguide within the circuit side of the aforementioned photograph nick crystal layer is made to reveal in a part for the trailer of this optical waveguide. The photograph nick crystal multilayer substrate characterized by being the mode converter which delivers a lightwave signal by combining this light wave made to reveal with the optical waveguide of another photograph nick crystal layer formed in a part for the trailer of the aforementioned optical waveguide by approaching.

[Claim 13] The photograph nick crystal multilayer substrate which is a photograph nick crystal multilayer substrate of the claim 12 aforementioned publication, and is characterized by consisting of optical waveguides which approached a part for a part for the trailer of the optical waveguide to which the aforementioned mode converter becomes thin the shape of a taper, and this trailer, and were formed in another photograph nick crystal layer.

[Claim 14] The process which carries out the laminating of the photograph nick crystal layer for forming a clad layer and a circuit on the 1st substrate one by one, The process which forms the optical circuit of the 1st layer in the aforementioned photograph nick crystal layer, and produces the 1st wafer, The process which carries out the laminating of a photograph nick crystal layer and the clad layer one by one on the 2nd substrate, and produces the 2nd wafer, The process which sticks the 1st wafer of the above, and the 2nd wafer so that the photograph nick crystal layer of the 1st wafer and the clad layer of the 2nd wafer may serve as a plane of composition, and produces the 3rd wafer, The process which removes the substrate portion of the 2nd wafer in the 3rd wafer of the above, The manufacture method of the photograph nick crystal multilayer substrate which forms a multilayer optical circuit in a photograph nick crystal layer by repeating the process which forms the optical circuit of the 2nd layer in the photograph nick crystal layer exposed after removing the substrate portion of the 2nd wafer of the above, and the aforementioned process two or more times.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the structures and those manufacture methods for realizing the structure and multilayering structure of the minute optical circuit by the photograph nick crystal, and multilayer light wiring about a photograph nick crystal multilayer substrate.
[0002]
[Description of the Prior Art] In recent years, the photograph nick crystal as two-dimensional [of the refractive index in the wavelength order of light] or the period structure of-dimensional [3] attracts attention. This photograph nick crystal hides possibility that 3 or more figures can make the size of the existing optical circuit small, and application to minute optical circuits including optical communication is expected. A photograph nick crystal can produce the photograph nick band gap which forbids propagation of a light wave to the light of a certain wavelength, if a line defect is introduced during the photograph nick crystal which has this photograph nick band gap, can confine a light wave in this line defect portion completely, and can also be used as an optical waveguide which makes light spread along with this line defect portion further.
[0003] There is the feature that flexibility of an optical-circuit pattern can be enlarged since it can respond also to steep bending as a feature of such a photograph nick crystall-luminescence waveguide, and the size can be further made small. Now, various optical devices including an optical waveguide are formed during this photograph nick crystal, and constituting a minute optical circuit is also considered.
[0004]
[Problem(s) to be Solved by the Invention] However, there are some technical problems in the photograph nick crystall-luminescence circuit as these conventional technology. First, since the concept of the conventional optical circuit was what is formed in a 1-time road surface, even if improvement in the circuit pattern flexibility by steep bending of optical wiring in a field was realizable using the photograph nick crystal, there was a limitation in the degree of integration.
[0005] Then, like multilayering of the electric wiring in the electronic integrated circuit on Si substrate, although multilayering of the optical wiring in an optical circuit had been considered for the purpose of improvement in a degree of integration, multilayering of optical wiring (optical waveguide) was not easy for the appearance of electric wiring. The reason is that a light wave closes also to the thing whose current [in / electric wiring / in the mechanism which confines a light wave in the interior of a waveguide] shuts up and which a mutual interference (cross talk) produces, and steep bending of an optical waveguide, and disclosure of a light wave will occur by part for the flection of the aforementioned optical waveguide like in optical wiring (optical waveguide) since eye ** is not perfect if two optical waveguides approach since it is not strong.
[0006] Furthermore, since there was a limitation in the scale of the optical circuit which can be formed in one layer naturally, it waited for multilayering of an optical circuit. However, the concrete structure and the manufacture method to multilayering of such an optical circuit did not have the former.
[0007] the purpose of this invention solves the technical problem of the optical circuit as these conventional technology, and offers the optical circuit like an electronic integrated circuit which the degree of integration by multilayering of wiring can improve [further] -- it is in things
[0008]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention adopted the following composition.
[0009] The photograph nick crystal layer which a refractive index becomes from the photograph nick crystal which has the structure modulated two-dimensional or periodically three dimensions in the size about [of light] wavelength, It

has the clad layer which consists of material into which a refractive index differs from the aforementioned photograph nick crystal. The photograph nick crystal multilayer substrate characterized by having the slab waveguide type photograph nick crystal structure which put the aforementioned photograph nick crystal layer in the aforementioned clad layer, and carrying out two or more laminatings of the aforementioned photograph nick crystal structure in the thickness direction.

[0010] In the photograph nick crystal multilayer substrate of the above-mentioned this invention, optical devices, such as an optical waveguide, an optical branch circuit, a light wave length filter, a light emitting device, and a photo detector, can be formed in two or more photograph nick crystal layers, and a multilayer optical circuit can be constituted.

[0011] Moreover, in the aforementioned photograph nick crystal multilayer substrate, it can also consider as the composition which consists of a multilayer which carried out the laminating of two or more kinds of matter with which refractive indexes differ the aforementioned clad layer by turns.

[0012] Or in the aforementioned photograph nick crystal multilayer substrate, it can consider as the composition which consists of a photograph nick crystal which has the structure where the refractive index was modulated two-dimensional or periodically three dimensions in the aforementioned clad layer. Although it is desirable to have had the engineering reflection property which has a big reflection factor to the light of specific wavelength as for this clad layer, it is more desirable that it is what has a big reflection factor to the light wave introduced into the optical device formed in the photograph nick crystal layer.

[0013] Next, in the aforementioned photograph nick crystal multilayer substrate, it can consider as composition equipped with the mechanism for delivering a lightwave signal between the optical devices formed in the photograph nick crystal layer from which this substrate differs.

[0014] Let the mechanism for delivering a lightwave signal between the optical devices of a layer different the account of a top be the mode converter changed so that the light wave which takes out or carries out incidence of the light wave spread along with the optical waveguide within a circuit side from the perpendicular direction of a circuit side to the perpendicular direction of a circuit side may be spread along with the optical waveguide within a circuit side.

[0015] Moreover, the above-mentioned mode converter is formed in a part for the trailer of the optical waveguide formed in the circuit side of the aforementioned photograph nick crystal layer, has the light wave which spreads the aforementioned optical waveguide, and the resonating mechanism, and can make them the mechanism which takes out the light wave which spreads the aforementioned optical waveguide to the perpendicular direction of a circuit side with the aforementioned resonance object.

[0016] Or the above-mentioned mode converter can consider the surroundings as the composition which consists of the resonance section prepared by surrounding a center [the light wave which spreads an optical waveguide, the resonating configuration, the hole which has a size, and its hole].

[0017] Or the mechanism for delivering the lightwave signal from the optical device formed in the circuit side of a photograph nick crystal layer to the optical waveguide formed in another photograph nick crystal layer The light wave spread along with the optical waveguide within a circuit side is made to reveal in a part for the trailer of the aforementioned optical waveguide, and it can consider as the mechanism in which signal light is delivered, by combining this light wave with another optical waveguide formed by approaching with a part for the trailer of the aforementioned optical waveguide.

[0018] Moreover, the above-mentioned mode converter can be made into the structure of delivering the lightwave signal from an optical device by the optical waveguide which approached the trailer and the aforementioned optical-waveguide trailer of the optical waveguide which becomes thin the shape of a taper, and was formed in another photograph nick crystal layer.

[0019] Next, the photograph nick crystal multilayer substrate of this invention can be manufactured in arbitrary lamination by the following methods. The process which carries out the laminating of the photograph nick crystal layer for forming a clad layer and a circuit on the 1st substrate one by one, The process which forms the optical circuit of the 1st layer in the aforementioned photograph nick crystal layer, and produces the 1st wafer, The process which carries out the laminating of a photograph nick crystal layer and the clad layer one by one on the 2nd substrate, and produces the 2nd wafer, The process which sticks the 1st wafer of the above, and this 2nd wafer so that the photograph nick crystal layer of the 1st wafer and the clad layer of the 2nd wafer may serve as a plane of composition, and produces the 3rd wafer, The process which removes the substrate portion of the 2nd wafer in the 3rd wafer of the above, The manufacture method of the photograph nick crystal multilayer substrate which forms a multilayer optical circuit in a photograph nick crystal layer by repeating the process which forms the optical circuit of the 2nd layer in the photograph nick crystal layer exposed after removing the substrate portion of the 2nd wafer of the above, and the aforementioned process two or more times.

[0020]
[Embodiments of the Invention] With reference to a drawing, the form of operation of this invention is explained in full detail below that the above and other purposes, the feature, and advantage of this invention should be made clear.
[0021] The composition of a slab waveguide type photograph nick crystal multilayer substrate which is the form of 1 operation of this invention, and its manufacture method are explained below. Moreover, how to form a multilayer optical circuit and multilayer light wiring in the aforementioned multilayer substrate is also explained.
[0022] Drawing 1 is the perspective diagram showing the slab waveguide type photograph nick crystal multilayer substrate as 1 operation form of this invention. In addition, although drawing 1 shows the photograph nick crystal multilayer substrate of two-layer structure as an example, in the multilayer structure of three or more layers, it is completely applicable similarly. The photograph nick crystal multilayer substrate shown in drawing 1 is the composition that the laminating of the 2nd photograph nick crystal layer 4 which consists of Si by which clad layer 2of clad layer 2a [of 1st SiO2], 1st photograph nick crystal layer [which consists of Si by which the optical circuit of the 1st layer was formed] 3, and 2nd SiO2 b, and the optical circuit of the 2nd layer were formed on the substrate 1 which consists of Si was carried out one by one.
[0023] In drawing 1 , the aforementioned photograph nick crystal layer 3 in which the optical circuit was formed has constituted slab waveguide structure in the thickness direction, and since it can be shut up in the photograph nick crystal layer into which the light wave was inserted by the clad layers 2a and 2b according to this structure, it can suppress the interference (cross talk) between the optical circuits of a photograph nick crystal layer.
[0024] Moreover, in the photograph nick crystal multilayer substrate shown in drawing 1 , the slab waveguide structure which is the adjoining slab waveguide structure and which uses the 2nd photograph nick crystal layer 4 as a core, and the slab waveguide structure which uses the 1st photograph nick crystal layer 3 as a core are the structure of sharing 2nd SiO2 clad layer 2b as a clad layer.
[0025] Moreover, in order to form slab waveguide structure, as for the refractive index of the clad layers 2a and 2b, it is desirable that it is smaller than the refractive index of the photograph nick crystal layers 3 and 4. That is, as for the average refractive index (refractive index of SiO2 : 1.5) of the material which constitutes the clad layers 2a and 2b of the above SiO2, it is desirable that it is smaller than the average refractive index (average of the refractive index of Si and air) of the photograph nick crystal layers 3 and 4 which are cores.
[0026] Next, the manufacture method of the photograph nick crystal multilayer substrate of this operation form shown in drawing 1 is explained with reference to drawing 2 . Drawing 2 (a) - (e) is cross-section structural drawing showing the manufacturing process of the multilayer optical integrated circuit of this operation form. First, as shown in drawing 2 (a), the SOI (Silicon on Insulator) wafer which carried out the SiO2 clad layer 6 of about 2-micrometer ** on the Si substrate (the 1st substrate) 5, and carried out the laminating of the Si layer of about 1-micrometer ** further on it is produced. Then, the 1st wafer is produced by forming the photograph nick crystal layer 7 and forming the optical circuit of the 1st layer in this photograph nick crystal layer 7 by opening the hole periodically located in a line with the aforementioned Si layer formed in the topmost part regularly.
[0027] In case the method of forming the aforementioned optical circuit processes topmost Si layer to the photograph nick crystal layer 7, it forms the method of writing the circuit pattern in the mask for crystal pattern processing beforehand, or the first uniform photograph nick crystal layer 7, and has the method of forming a circuit pattern by etching, embedding, etc. afterwards.
[0028] next, it is shown in drawing 2 (b) -- as -- the Si substrate (2nd substrate) 8 top -- the SiO two-layer of about 0.2-micrometer ** -- 9 -- a it top -- the Si layer 10 of about 1-micrometer ** -- a it top -- further -- the SiO two-layer of about 2-micrometer ** -- the 2nd wafer which carried out laminating formation of 11 is produced, and it sticks with the 1st wafer shown in drawing 2 (a), and considers as the 3rd wafer this time -- the photograph nick crystal layer 7 of the 1st wafer, and the SiO two-layer of the 2nd wafer -- 10 is made to counter and it joins In addition, already established technology, such as thermocompression bonding, can be used for the lamination of the above 1st and the 2nd wafer.
[0029] next, it is shown in drawing 2 (c) -- as -- the SiO two-layer of the Si substrate 8 of the 3rd wafer of the above, and about 0.2-micrometer ** -- etching removes 9 and the Si layer 10 is exposed Then, as shown in drawing 2 (d), the Si layer 10 exposed to the front face is processed to the photograph nick crystal layer 12 by the method of point **, and the optical circuit of the 2nd layer is formed in this photograph nick crystal layer 12. In addition, the method of forming the aforementioned optical circuit is the same as the method of a publication previously.
[0030] Furthermore, it is possible to carry out the laminating of the optical circuit to many layers on Si substrate by repeating the manufacturing process shown in drawing 2 (b) - (d).
[0031] By the way, since the optical interference between adjoining optical circuits has taken the slab waveguide structure which put the photograph nick crystal layer in the clad layer, although it can be suppressed somewhat small, in order to suppress the aforementioned optical interference more completely, it is desirable [interference] to also

consider the clad layer between each circuit as the composition which consists of a photograph nick crystal which has a photograph nick band gap. Drawing 3 (a) - (c) is drawing showing the photograph nick crystal multilayer substrate which is the form of other operations of this invention, and the perspective diagram in which drawing 3 (a) shows the photograph nick crystal multilayer substrate of this form, the fragmentary sectional view in which drawing 3 (b) shows an example of the composition of a clad layer, and drawing 3 (c) are the fragmentary sectional views showing other examples of composition of a clad layer.

[0032] As shown in drawing 3 (a), the photograph nick crystal multilayer substrate of this form is the composition that laminating formation of clad layer 14a, photograph nick crystal layer 15a, clad layer 14b, photograph nick crystal layer 15b, clad layer 14c, photograph nick crystal layer 15c, and the 14d of the clad layers was carried out one by one on the substrate, and is the photograph nick crystal multilayer substrate produced by the manufacture method of the photograph nick crystal multilayer substrate explained above.

[0033] In this form, although the 3-dimensional photograph nick crystal structure which is the wavelength range of the light wave introduced into an optical circuit as a photograph nick crystal used as clad layers 14a-14d, and has a perfect band gap is desirable, it can also consider as the 1-dimensional photograph nick crystal (multilayer) 16 shown in drawing 3 (b), or the two-dimensional photograph nick crystal 17 shown in drawing 3 (c). What is necessary is just to design by thickness which fulfills Bragg-reflection conditions to the light which carries out incidence at right angles to the aforementioned multilayer, in using the 1-dimensional photograph nick crystal (multilayer) 16.

[0034] In addition, in the operation form or other operation forms of this invention explained above, as a material which carries out a laminating on Si substrate, although Si (photograph nick crystal layer)/SiO2 (clad layer) were shown, structure with the same said of the case where the layer which consists of AlGaAs system material is formed on the substrate of GaAs, and the case where the layer which consists of InGaAsP system material is formed on the substrate of InP is applicable.

[0035] Next, the method of realizing delivery of a lightwave signal is explained using drawing 4 -6 between the optical circuits formed in the photograph nick crystal layer in a photograph nick crystal multilayer substrate. Although the photograph nick crystal substrate multilayered by the composition shown in drawing 1 and the manufacture method shown in drawing 2 is realizable according to this invention, it can consider as the composition equipped with the mechanism in which the lightwave signal between the layers at the time of multilayering the composition equipped with the mechanism in which a lightwave signal is delivered between the optical circuits of each photograph nick crystal layer, or an optical circuit is delivered. An example of the structure of a mode converter which can perform delivery or ****** contact of a lightwave signal to drawing 4 is shown.

[0036] Drawing 4 is the perspective diagram having expanded and shown an example of the mode converter formed in the photograph nick crystal layer 3 of the photograph nick crystal multilayer substrate shown in drawing 1 . In the photograph nick crystal layer 3 by which the mode converter shown in drawing 4 was inserted into the clad layers 2a and 2b The configuration which resonates on the wavelength of the light wave (lightwave signal) 18 which spreads optical-waveguide 18a, and hole 19a which has a size, It is the composition which consists of the resonance section 19 which consists of the non-processed section in which the photograph nick crystal prepared by surrounding the surroundings focusing on this hole 19a is not formed, and this resonance section 19 is connected to a part for the trailer of optical-waveguide 18a within a field.

[0037] Operation of this mode converter is changed so that the light wave which takes out or carries out incidence of the light wave 18 spread along with optical-waveguide 18a within the circuit side of the photograph nick crystal layer 3 in the direction perpendicular to a circuit side at right angles to a circuit side conversely may be spread along with optical-waveguide 18a within a field. Since resonant wavelength is changeable with the size and configuration of hole 19a where it is located at the center of the resonance section 19 in the case of this mode converter, delivery of the lightwave signal corresponding to the light wave 18 to be used is possible by choosing the size and configuration appropriately according to the wavelength of the light wave 18 introduced in optical-waveguide 18a.

[0038] Moreover, in the optical wiring formed in a different photograph nick crystal layer of a photograph nick crystal multilayer substrate, if this mode converter 24 is arranged to two places in the form which counters the part which needs to deliver a lightwave signal (optical combination), delivery of the lightwave signal between layers is realizable. Delivery of the aforementioned lightwave signal is performed by operation as shown below. For example, the light wave spread along with the optical waveguide within the circuit side of the optical circuit formed in the 1st photograph nick crystal layer is taken out to the perpendicular direction of a circuit side with the 1st mode converter, and it changes into the light wave which carries out incidence perpendicularly to the 2nd photograph nick crystal layer. The light wave which carries out incidence at right angles to the circuit side of the 2nd above-mentioned photograph nick crystal layer is led to the optical waveguide within the circuit side of the 2nd photograph nick crystal layer with the 2nd mode converter continuously arranged in the form which counters the 1st mode converter of the above. Thus, the light

wave which spreads the inside of the circuit side of the 1st photograph nick crystal layer can be drawn in the circuit side of the 2nd photograph nick crystal layer.

[0039] The mode converter which carries out the above-mentioned operation can be used combining field luminescence laser (VCSEL:Vertical Cavity Surface Emitting Laser), as shown in drawing 5 . Drawing 5 is drawing showing one form of the photograph nick crystal multilayer substrate of this invention equipped with the mode converter combined with Above VCSEL, drawing 5 (a) is drawing showing the partial cross-section structure of the aforementioned photograph nick crystal multilayer substrate, and drawing 5 (b) is the perspective diagram of the aforementioned photograph nick crystal multilayer substrate.

[0040] In drawing 5 (a), the photograph nick crystal multilayer substrate of this form is the composition that the laminating of the photograph nick crystal layer 23 and clad layer 22of SiO2 b by which the optical circuit containing clad layer 22a of SiO2 and a mode converter 24 was formed on the substrate 21 of InP which has VCSEL20 was carried out one by one. In the photograph nick crystal multilayer substrate of this form shown in drawing 5 (a) and (b), incidence of the outgoing radiation light from VCSEL20 is carried out to a mode converter 24 from the perpendicular direction of a circuit side, and the aforementioned mode converter 24 operates so that the light wave which carried out incidence may be led to optical-waveguide 18a formed in the circuit side.

[0041] Or if it replaces with VCSEL20 and a field incoming-radiational-type light sensitive cell is arranged in the aforementioned substrate 21, the aforementioned mode converter 24 can take out the light wave spread along with optical-waveguide 18a within a circuit side in the direction perpendicular to a field, and can carry out operation led to the aforementioned field incoming-radiational-type light sensitive cell.

[0042] On the other hand, the aforementioned mode converter can also be considered as the composition which leads planar type semiconductor laser and the light of a light emitting device to the optical waveguide in a circuit, or operates so that the light from an optical waveguide may be conversely led to planar type a device besides a photo detector. Above-mentioned composition and above-mentioned operation are explained below with reference to drawing 6 .

[0043] Drawing 6 shows one form of the photograph nick crystal multilayer substrate of this invention equipped with the mechanism for leading the light wave from an optical planar type device to the optical waveguide within the circuit side of a photograph nick crystal layer, drawing 6 (a) is drawing showing the partial cross-section structure of the photograph nick crystal multilayer substrate of this form, and drawing 6 (b) is the perspective diagram of the photograph nick crystal multilayer substrate of this form. The photograph nick crystal multilayer substrate of this form shown in drawing 6 (a) and drawing 6 (b) is the composition that the laminating of the photograph nick crystal layer 28 and clad layer 27of SiO2 b by which clad layer 27a, the mode converter 29, and optical circuit of SiO2 were formed on the substrate 26 of InP which has the planar type semiconductor laser 25 was carried out one by one. In addition, the aforementioned mode converter 29 is arranged in the aforementioned photograph nick crystal layer 28 in the position which counters point 25a of the aforementioned planar type semiconductor laser 25.

[0044] In the photograph nick crystal multilayer substrate of this form shown in drawing 6 , delivery between layers of a light wave can be performed by combining a part of two waveguides optically. Since point 25a of the planar type semiconductor laser 25 shown in drawing 6 (a) has the taper type optical waveguide of a configuration to which the thickness becomes thin the shape of a taper toward a nose of cam, from the aforementioned planar type semiconductor laser, a light wave is emitted in the direction perpendicular to taper side 25b at the aforementioned nose of cam with the property that a light wave oozes out and tends to be emitted from the aforementioned taper type optical waveguide if the point of an optical waveguide is made thin. Here, since the optical waveguide is formed in the position which counters taper side 25b of point 25a of the aforementioned planar type semiconductor laser 25 at the aforementioned photograph nick crystal layer 28, the disclosure light from the aforementioned planar type semiconductor laser is drawn into the aforementioned optical waveguide, and is changed into the light wave which spreads the inside of the circuit side of the photograph nick crystal layer 28. The outgoing radiation light of the aforementioned planar type semiconductor laser is combinable with the aforementioned optical waveguide with the above operation.

[0045] In addition, it is clear that this invention is not limited to each above-mentioned operation form, and each operation form may be suitably changed within the limits of the technical thought of this invention.

[0046]

[Effect of the Invention] As mentioned above, since according to this invention a slab type optical waveguide can be constituted by the ability using as a clad layer the material from which a photograph nick crystal and a refractive index differ and material with a desirable refractive index smaller than the refractive index of the aforementioned photograph nick crystal, for example, one dimension, and a two-dimensional photograph nick crystal and this slab type optical waveguide can be multilayered as explained in detail, improvement in the remarkable degree of integration of an optical integrated circuit is realizable.

[0047] Furthermore, the photograph nick crystal multilayer substrate of this invention The mechanism which resonates

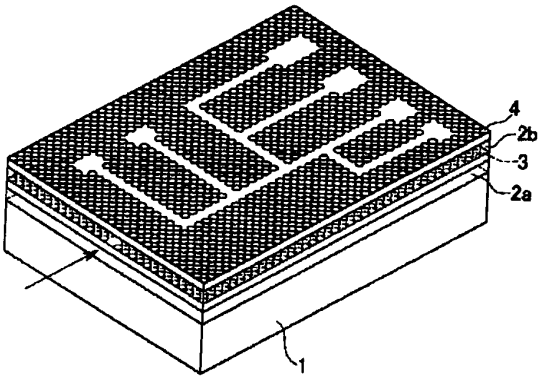
to the light wave which spreads the optical waveguide to a part for the trailer of an optical waveguide, i.e., the configuration which resonates to the aforementioned light wave, and the hole which has a size, It considers as the composition equipped with the optical propagating-mode converter which consists of the resonance section which is the non-processed section prepared in the surroundings of it. The mechanism in which signal light is delivered by making it combine with other waveguides which are made to reveal the light wave which spreads an optical waveguide, and approach, Namely, since the nose of cam of the optical waveguide of an optical device can be made thin the shape of a taper and it can consider as the composition equipped with the optical propagating-mode converter which delivers signal light to another optical waveguide close to the aforementioned point, Delivery of the lightwave signal between the layers in a photograph nick crystal multilayer substrate is realizable.

[0048] According to the manufacture method of the photograph nick crystal multilayer substrate of this invention, on the 1st substrate Moreover, a clad layer, The process which carries out laminating formation of the photograph nick crystal layer for forming a circuit one by one, The process which carries out laminating formation of a photograph nick crystal layer and the clad layer one by one on 2nd substrate with another process which forms the 1st optical circuit in the aforementioned photograph nick crystal layer and this, The process which makes the 1st wafer of the above, and the 2nd wafer rival, and the process which removes the substrate portion of the 2nd wafer after that, The photograph nick crystal multilayer substrate which has arbitrary lamination can be manufactured by repeating the process which forms the 2nd optical circuit in the photograph nick crystal layer which appears after removing the aforementioned substrate portion two or more times.

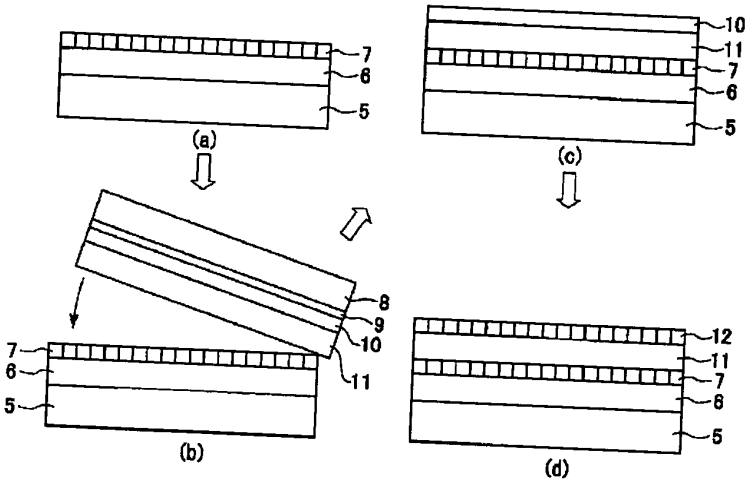
[Translation done.]

DRAWINGS

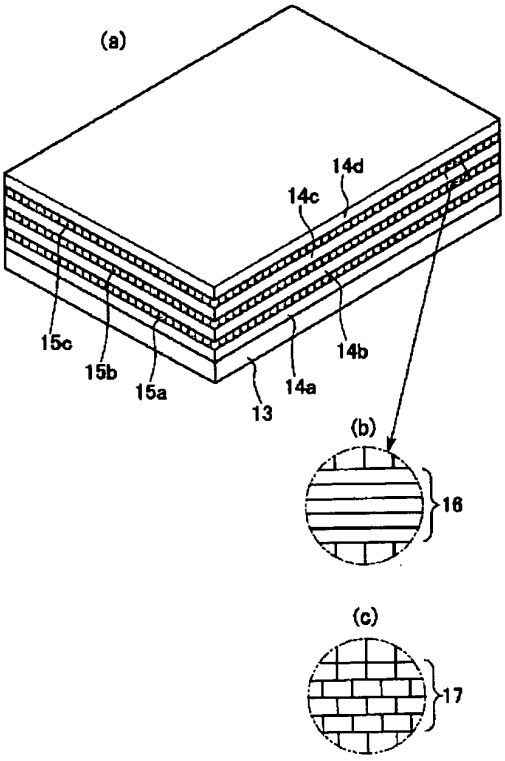
[Drawing 1]



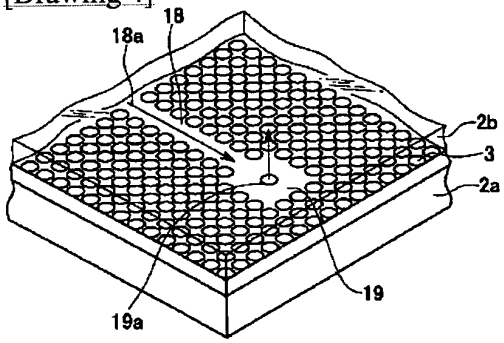
[Drawing 2]



[Drawing 3]

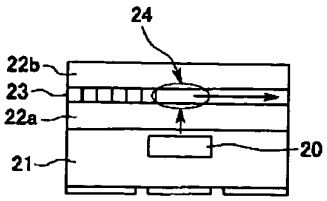


[Drawing 4]

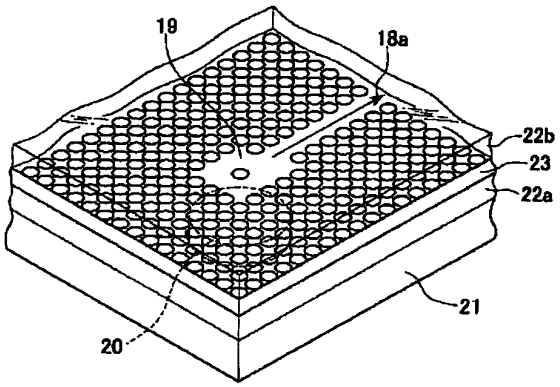


[Drawing 5]

(a)

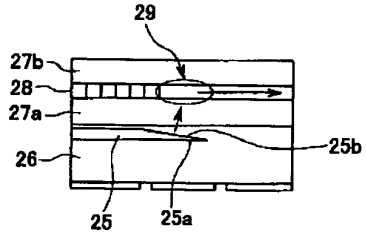


(b)

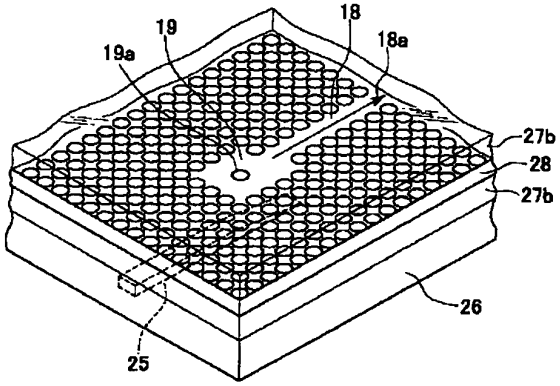


[Drawing 6]

(a)



(b)



[Translation done.]